Commentaries

Describing Values in Relation to Choices in LCA

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Abstract

Intention, Goal, Scope, Background. It has gained growing acceptance in recent years that there are values in LCA, and several authors have discussed how value orientations can influence LCA models and results. The aim of this article is to continue this discussion and to focus on value choices in LCA.

Objectives. To find a way of describing value orientations in relation to choices in LCA.

Methods. This objective has been pursued in this paper by investigating the relationship between values and traditional science, exploring the concept of values, investigating the relationship between values and choice, and suggesting a way to describe the value base for specific choices in LCA.

Results and Discussion. Research on how to improve the environmental performance of products resembles peace research in that it aims to achieve a certain value-laden situation in society. The epistemological basis for peace research also seems to apply to LCA research. The term value has many meanings. There are several classification methods for values and I claim that one is more suitable for choices in LCA than the others. The correlation between values and choice is not straightforward, and values can only partially explain choices.

Conclusions. Describing the value base for choices in LCA increases the consistency and transparency of the value choices and offers a means of justifying them.

Recommendations and Outlook. It is recommended that the value base is described in terms of 1) what is included in the concern for the environment 2) how tradeoffs are made and 3) how uncertainty is handled.

Keywords: Documentation format; ethics; life cycle impact assessment (LCIA); theory of science; valuation; values; weighting

Introduction

LCA has been developed with an ambition of describing environmental impacts of products and product systems. In the early days, LCA was mainly about mass and energy balances (Hunt et al. 1996). After some time, it was discovered that different LCAs of the same product system gave different results. LCA experts and users began to argue about right and wrong, and demands for 'scientific LCAs' were heard. Parallel to this, LCA began to be used as a tool for product development. Designers, who have many requirements to consider, saw the environmental aspect as one of many others and wanted a measure of all the added impacts. This led to the development of methods for weighting and aggregating different impacts to one number. The introduction of weights and values into LCA was objectionable to many (e.g. Schmidt et al. 2002). Voices demanding science-based LCA claimed that weighting should not be done, as it introduced subjective elements and decreased inter-study comparability. The conflict between these two viewpoints was made very clear during the consensus-oriented work in ISO, when the standards ISO 14040–43 were being written. The famous sentence in ISO 14042: "Weighting shall not be used for comparative assertions disclosed to the public" is proof of this, and proof that the conflict has not really been resolved.

The ISO standards for LCA contain several formulations indicating that the general view of the role of science in LCA is seen very simplistically. The term 'scientific' is used more or less synonymously with 'correct'. The impact assessment, and in particular weighting, is considered to be 'subjective', and the standard says: "subjectivity should be minimized". The ISO standard requires identification and reporting of all so-called 'value-choices'. There is also a special term 'technical assumptions' for some choices presumably thought of as not value laden. Hertwich et al. (2000) delivered a sharp criticism of how value issues are approached in the ISO standards.

Since 1995, several authors have addressed the issue of values in LCA. Volkwein et al. (1996b) address ethics and LCA, and suggest the use of human rights and international law and conventions as a base for valuation (Volkwein et al. 1996b). Finnveden (1997) looks at some weighting methods and asks, "Where are the values?". He discusses how different views of society, ethics and nature lead to different choices of weighting methods. Bengtsson (2000) notes that the fact that different weighting methods do not always agree is not a shortcoming attributable to subjectivity, but reflects real diversity in ways of looking at impacts. Many authors point out that value issues also influence choices made in the LCI phase (Hertwich et al. 2000, Werner et al. 2002). In the SETAC working group on impact assessments, there is a consensus that value issues play an important role in LCA (Finnveden et al. 2002).

Beltrani (1997) discusses safeguard subjects as moral objects and how these vary with different views of the environment such as anthropocentrism, pathocentrism (the be-

lief that moral subjects are qualified through their capacity of having sensations and experiencing pain), biocentrism and holism.

One well-known example of value characterisation is the introduction of cultural science (Hofstetter et al. 2000). Human beings are classified according to their worldviews, attitudes, and management styles as hierarchists, egalitarians, individualists and fatalists. As the authors point out there is a weakness in the theoretical base, but it has great strength in communication. It is easy to say: "From an egalitarian point of view, A is better than B". This is also in agreement with a common need in product development: to identify different customer groups and describe them in different ways.

Another culturally oriented starting point for value systematics is described by Galtung (1996a) as 'deep culture' . Deep culture is defined as "collectively held subconscious ideas about what constitutes normal and natural reality". It plays an important role when there is uncertainty and stress, as in conflict situations. He identifies six deep cultures with respect to their views on nature, self, society, world, time, transperson and episteme:

- Occident I, centrifugal, in expansion (Greco-Roman, Modern)
- Occident II, centripetal, in contraction (Medieval)
- Indic (Hindu)
- Buddhic (Buddhist)
- Sinic (Chinese)
- Nipponic (Japanese)

From this brief review of the literature on values within and outside the LCA community, it seems reasonable to justify our value choices in an LCA by describing their value bases, so that it can be used in practice in a way that satisfies scientific standards. The aim of this article is to find such a method for describing the value base in LCA. This will be done by:

- investigating the relationship between value issues and traditional empirical science in LCA,
- exploring the value concept,
- investigating the relation between values and choice,
- seeking a way to describe the value base for specific choices in LCA.

1 Values and Science in LCA

Traditional science is about theories and experiments. Sometimes theories are created to explain experimental results. Sometimes experiments are used to test theories. Any law or theory has to be accompanied by instructions for when it is valid. One common idea is that theories should be falsifiable. But falsifiability is not a complete description of science. Not all statements, for example Darwinian theory, are falsifiable (Boulter 1999). In LCA, there are also several impact models that predict changes that will occur some time in the far future and that we cannot test. These theories can still be acceptable if they are in agreement with other linked theories, in spite of the fact that they are not falsifiable.

Hertwich et al. (2000) discuss the theoretical foundations for LCA, in particular with respect to the role of values, and in the context of decision making. By making an analysis of the GWP-indicator they demonstrate that "any impact assessment method inevitably contains not only constitutive and contextual values, but also preference values". They suggest that "the ultimate criterion for method choice is whether a given method is better than its alternatives in improving the decision".

An LCA is carried out because we want to achieve something that is value laden, i.e. to improve the environment. In that sense LCA research resembles peace research. Galtung (1996b) developed an 'epistemological basis' for peace research. In addition to data and theories, values play an important role. Galtung uses a triangle to illustrate his concept (**Fig. 1**).

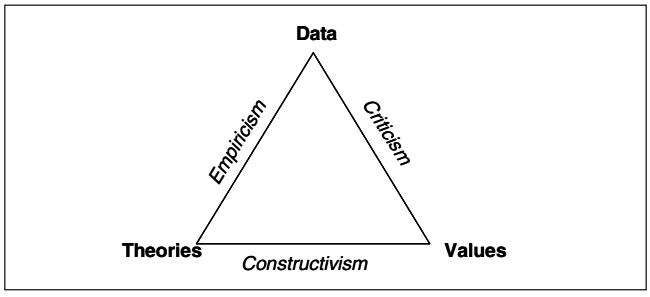

Fig. 1: Data-theory-values triangle (Galtung 1996b)

Data divides the world into the observed and the unobserved. An LCI is mainly a compilation of data. Many of the models used in LCIA are dependent on environmental data and data about human behaviour.

Theories divide the world into the foreseen and the unforeseen. Emission models relating emission data to production data and characterisation models relating category indicators to emissions are examples of theories.

Values divide the world into the acceptable and the unacceptable. Weighting factors are not values in this sense. They are data used in theories, e.g. relating data on revealed preferences to category indicators. The types of values mentioned in Fig. 1 are deep underlying ideas representing ideals. They may be identified using psychometric tests, where choice plays an important role (Shields et al. 2002).

The science of linking data to theories is **empiricism**. It is at the core of natural science. When it is successful, all observed data are foreseen by theories, while unobserved data are unforeseen. Impact models and emission models in LCA are based on empiricism.

The science in which data is linked to values is **criticism** and is a core element of social science. Is what we observe acceptable or unacceptable? In LCA the choice of impact categories and elementary flow types are based on criticism. We would typically not include those parameters if they did not say something about an unacceptable impact on the environment.

When theories are linked to values we may speak of **constructivism**. This is the core of engineering science. When it is successful, the foreseen is acceptable and the unacceptable unforeseen. In LCA, improvement assessments and DFEs (designs for environment) are examples of constructivism. (The term constructivism is also used in another meaning in science about learning. Learners are thought to construct new ideas or concepts based upon their current/past knowledge).

Neither theories nor data can exist entirely independent of values. Someone wants the data. Neither theories nor values can exist without data. Values and data can, in principle, exist without theories. But they seldom do – for long. In other words: data prevail over theories and values prevail over data. Perhaps one can say that theories and data (=experiences) influence our values in the long run.

One dramatic illustration of how data is dependent on values is given by Nørretrander (1993). Using our five senses, we can receive about 11 MB of information each second, most of it through our eyes. We can only consciously handle a maximum about 40 bytes/second and normally we handle 10–20 bytes/sec. This means that we are dependent on subconscious processes to sort out almost every piece of information we receive from our conscious minds. What we ultimately focus on depends very much on what we consider valuable information to us.

2 The Value Concept(s)

The term value means different things to different people and in different contexts. In LCA it is also used in many senses. Sometimes it simply means a quantity. For example, "The value read on the monitor was 13.4". Sometimes we use it to express concern or interest, e.g. "I value clean air more than cars". Sometimes the term value is used to describe moral beliefs. There are several ways of classifying values.

Hertwich et al. (2000) refer to Shrader-Frechette (1991) and distinguish between constitutive values, contextual values and preference values. **Constitutive values** are beliefs in theories and paradigms, **contextual values** are related to a specific situation. They influence the selection of one specific method or data set rather than the alternatives. **Preference values** express what we care about. Hertwich et al. relate these value classes to different types of claims made in an LCA, including factual, normative and relational claims. Constitutive and contextual values influence factual claims, while preference values influence normative claims and, with some factual information, relational claims.

Schields et al. (2002) cite Brown (1984) who uses the term **held values** to denote "morals, beliefs, conduct, qualities and states that individuals and groups consider desirable". These differ from **assigned values**, which "are derived from held values and refer to the worth or importance (monetary or otherwise) attributed to an object, state or behaviour". **Intrinsic values** (also called terminal values, e.g. human health) are values in themselves, and different from **instrumental values**, which exist to fulfil intrinsic values. Intrinsic values may be further divided into personal values (happiness, freedom) and social values (equality, sense of community). Instrumental values may be moral values (honesty, kindness) or competence values (logic, rationality) (Rokeach 1973). This hierarchy is illustrated in **Fig. 2**.

Assigned values are sometimes used for weighting and for systematic selection of LCI and LCIA parameters to be included in an LCA study. They are related to behaviour (e.g. choice) via needs, wants, preferences, satisfiers and intentions (Fransson et al. 1999). A want is generated from an unsatisfied need, whose satisfier may have an assigned value.

Held values have also been defined as "beliefs pertaining to desirable end states or modes of conduct that transcend specific situations and guide choices of actions". Human rights are moral values. Moral values are closely related to norms. A norm may be defined as "an expectation held by an individual about how he or she ought to act in a particular social situation" (Fransson et al. 1999). If shared by a group we may speak about a social norm. For practical purposes, **value orientations** are often used to describe moral values. They refer to clusters of prioritised values. Moral values are stable in time and are often retained throughout a person's lifetime. There is a correlation between moral values and behaviour in environmental issues (e.g. choice of green products), but it has been shown to be relatively low (Fransson et al. 1999). The authors suggest that environmental concern defined in a general way (i.e. attitudes about targets)

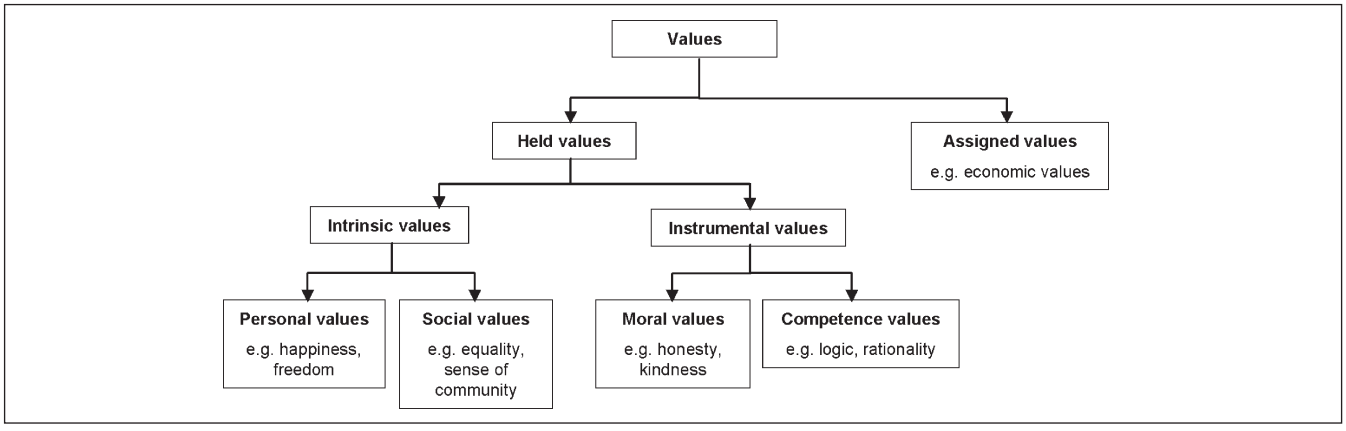

Fig. 2: Hierarchy of values (Shields et al. 2002)

and defined more narrowly (i.e., attitudes about specific pro-environmental behaviours) also have some influence, as do factors such as habits, norms, situational constraints and anticipated outcomes of the behaviour.

From an evolutionary point of view, values orientations may be seen as ideas based on generations of experience that guide us to satisfy basic needs in a social context. But if past experience is not relevant to the problem at hand (as in the case of sustainability), an awareness of which values guide us, and what they stand for, is crucial. Scientific understanding can influence values (Shields 2002).

When discussing environment, value orientations are sometimes expressed as **egocentrism**, **anthropocentrism**, **altruistic anthropocentrism** and **ecocentrism**. An egocentric person maximizes his or her own personal benefits. An anthropocentric person regards nature as a resource for human needs. An altruistic anthropocentric person has the same basic view as an anthropocentric person, but sees things in a wider perspective and is more cautious. An ecocentric person gives nature a value of its own. In practical behaviour, not much difference has been found between an altruistic anthropocentric person and an ecocentric one (Fransson et al. 1999).

Axelrod (1994) proposed a taxonomy of values, where people are classified into three motivational domains: economic, social, and universal. He shows them to differ systematically in their responses to hypothetical dilemmas involving ecological issues.

For any value-holder, needs play an important role, particularly 'basic needs'. Values are very much linked to needs via 'satisfiers'. Satisfiers for unfulfilled needs are highly valued. Satisfiers for fulfilled needs are less highly valued. The relationship between needs satisfaction and the value of a satisfier is not linear. Basic needs are common to all people, but the appreciation of their value varies greately from person to person even at the same level of satisfaction. Hunger may be a major threat to those who have experienced starvation, while those used to having easy access to food do not mind being hungry. There is extensive literature on human needs, (Douglas 1998). One of the first lists of human needs was formulated by Maslow, who created a needs hierarchy starting with the need for food and water, and ending with the need for knowledge for its own sake. Modern needs science has abandoned much of Maslow's view of needs. **Table 1** gives a list of basic needs as formulated by Galtung (1996c).

Table 1: Basic needs and satisfiers (Galtung 1996c)

Basic human needs	Satisfiers
Integrity of the human body	Trauma protection
Input of (clean) air, water and nutrition	Air, water, food
Input of (pleasant) stimuli, visual, auditive, olfactory	Pleasant environment
Output of waste products, excretion	Latrines, etc.
Temperature, humidity, wind control	Clothing, shelter
Sleep, rest	Quiet
Movement	Space
Sex	Privacy
Reproduction	All of the above

In addition to the basic needs in Table 1, there are needs for different types of skills: physical as well as mental. One very important need is 'identity'. Relations to other people are more important than food in some contexts.

3 Choice

Munthe (1997) has described choices in relation to ethics in agriculture as being based on three positions taken:

1. What to include in the concern
2. How to make tradeoffs
3. How to handle uncertainty.

This may also be suitable for LCA, in particular when comparing products.

3.1 What to include

System borders define what is included. Normally an LCA only contains information on system borders in the technical system, as a part of the LCI. Forsberg (2003) has suggested a way of describing system borders systematically by identifying components of both the outer and the inner system (e.g. time, function, flows, etc.).

There are several components in relation to which system borders may be drawn in LCIA:

- objects (at different system levels),
- time,
- space,
- position in cause-effect chains.

Human health, environmental health and natural resources are objects normally included in an LCA. Sometimes cultural objects and economic values are considered. These types of objects are sometimes referred to as 'safeguard subjects'. Objects exist at different levels, from molecular to social and global. From a historical point of view, early human beings had a very narrow set of safeguard subjects. Their health and well-being, and possibly those of their family, was difficult enough to manage. As human wealth and knowledge grew the numbers of objects cared about also increased. Singer (1975) has coined the term 'moral circle' for what encompasses our moral objects.

Time is dealt with very differently in different LCAs. This has dramatic consequences for the appreciation of the value of our mineral reserves. Most of our mineral reserves will last for more than 100 years, and between now and then there will be no resource problems. If we only consider impacts (problems) during the next 100 years the state of the environment with respect to mineral reserves will be deemed to be acceptable. If we consider, the impact on environment for the next 10,000 years today's impact levels will be judged to be highly problematic.

3.2 How tradeoffs are made

There are two principal ways of making tradeoffs:

1. A common denominator is used for all parts and they are compared according to their quantitative representation in the chosen unit.

2. An acceptable (reference) state is defined for each part, and the relative distance to the reference state is used to measure unacceptability.

Number one assumes that parts are exchangeable, as in economic theory. The value-orientation underpinning this is normally called utilitarianism. Number two is more of a 'justice' approach and ascribes unique values to all parts. In LCIA the first corresponds to monetary weighting methods like the EPS 2000 default method (Steen 1999), while the second corresponds to 'distance-to-target methods' like the Ecoscarcity method (BUWAL 1998). In reality many trade-offs use a combination of 1 and 2.

3.3 Handling uncertainty

The precautionary principle is often advocated in environmental policy (Agenda 21). As long as only a single issue is on the agenda, such as regulating the use of a toxic substance, it may be uncontroversial. But in LCA, where several issues are considered at the same time, taking precautions for one may mean taking fewer precautions for another. Still, there is a basic difference in people's approaches to uncertainty in terms of precaution, i.e. how far the precautionary principle is driven. There is also a difference in awareness when it comes to uncertainty. One extreme position is not to consider it at all: collect the best data you can and that will have to do. Another extreme is to model all uncertainty, real variance as well as lack-of-knowledge-uncertainty, and then make Monte Carlo simulations to find out what different data values mean to the results.

4 Describing Value Choices in LCA

There are several types of value choices in LCA such as the choices of:

- carrying out an LCA,
- goal,
- system borders in LCI,
- elementary flows to investigate in LCI,
- allocation principle in LCI,
- safeguards subjects, impact categories and category indicators,
- characterisation methods,
- normalisation methods,
- grouping methods,
- weighting methods.

There are thus many steps where value orientations play a role. A consistent value pattern through the whole LCA clearly favours transparency. In **Table 2**, I have applied two current value orientations called strong and weak sustainability when making choices in LCA. Strong sustainability implies the idea of a natural capital consisting of many unique values in the environment that have to be protected and a high degree of precaution, while weak sustainability implies the idea that the natural capital is built up on the basis of exchangeable goods. For a further description of strong and weak sustainability see for example Ekins et al. (2003).

The exercise presented in Table 2 indicates that describing the value base for strong and weak sustainability in terms of the three aspects put forward in chapter 4 significantly influences the choices made. This is partly in contradiction to Fransson et al. (1999), which indicated a low correlation between value orientation and real life choices (typically by consumers). From this, I draw the following conclusion: General description of held values is not enough to justify choices made in an LCA. We need to describe aspects of held values relevant for specific choices in LCA and we need to make it systematically in close connection to the choices. Otherwise other considerations like habits, may influence the choice.

The decision to carry out an LCA and the choice of goal is likely to be driven by an environmental concern, but may of course also be made for pure economic reasons. With a weak sustainability value base, the added value of the impact would be of interest and presumably leading to fewer LCAs than with a strong sustainability base. Choices of system borders and allocation rules in the LCI phase are inherently value laden, although in current practice they seem more often to be dictated by practical considerations than by derived or held values. But following the recommendation by ISO to justify the choices made, including processes, flows, time periods and areas to include, value orientations may play a

Table 2: Outcome of a test to derive value choices from a value orientation corresponding to strong and weak sustainability

Choice in LCA procedure	How can values influence choices?	
	Strong sustainability	**Weak sustainability**
The decision to carry out an LCA	Positive, if any of the impacts can be suspected to be significant	Positive, but only if impacts together are significant
Goal	To include improvement assessment and a high level of ambition in the LCA	Towards improvement of added impact
System borders in LCI	To make them as wide as possible	To focus on significant processes
Elementary flows to investigate in LCI	To include as many as possible	To focus on flows with significant impacts
Allocation in LCI	To use average contributions	To use marginal contribution
Safeguards subjects, impact categories and category indicators	To include as many as possible, but what are considered to be moral objects may vary and need specification.	To focus on significant impacts, but what is included may vary and need specification.
Characterisation methods	To use average contribution	To use marginal contribution
Normalisation methods	To use a reference state for each indicator	Normalisation becomes a part of weighting
Grouping methods	?	?
Weighting methods	Distance to target, but no aggregation	Aggregation to one number

more significant role. Again, with a weak sustainability base one would be more focused on significant issues than with a strong sustainability base. The choice of allocation method does not follow directly from the value base of strong and weak sustainability, but there is more acceptance for tradeoffs in weak sustainability. Average means tradeoffs over time. When selecting safeguards subjects, impact categories and category indicators, held and derived values may be expected to play an important role, while when choosing characterisation, normalisation and grouping methods, practical considerations again become decisive. Finally, the choice of weighting method is strongly linked to held and derived values, both because of the nature of weighing and because of the spread of held values present today in society. Weak sustainability favours tradeoffs in one dimension and may lead to choices of for example monetary weighing methods, while strong sustainability acknowledges many different values and thus favours distance to target methods.

In ISO 14042 (ISO 2000), there is a requirement for justification of value-choices. If the correlation between value choices in LCA and generally held values in society is weak, we need another focus and resolution of value alternatives. So what values or ideas are relevant for value choices in LCA?

Munthe structured ethical aspects regarding relation to choice in agriculture. Choices in agriculture resemble choices in environmental issues in many ways. The moral objects are similar and there is a similar trade-off between present human interests and the interests of animals, plants and future generations. Below, Munthe's three ethical considerations regarding choices in agriculture are used as a way of describing the value base for choices in LCA. The value base is further illustrated as a graphic 'value space'.

The value space in **Fig. 3** is designed by transforming ethical views into scalars. This is, of course, a gross oversimplification, but properly used it may help us to get a picture of the approximate value orientation. The Y-axis is important for tradeoffs. At the low end is a utilitarian view, where things are exchangeable. This means that there is only one unique value, e.g. money. At the upper end several categories are identified, for which values and demands for acceptability

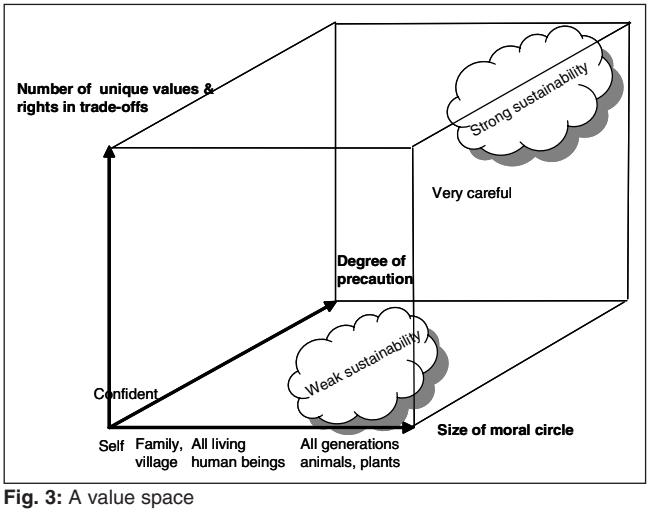

Fig. 3: A value space

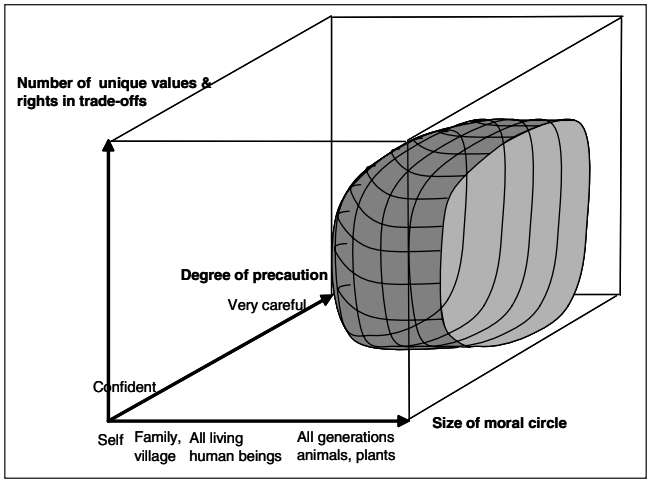

Fig. 4: Ethical views most relevant for LCAs (shaded volume)

are given. The X-axis describes the size of the moral circle. It is a simplification only to show the size, when in principle the same size may contain different objects. The Z-axis describes the degree of precaution.

Value orientations such as strong and weak sustainability may be shown in Fig. 3 as shaded volumes.

The choice to make an LCA indicates two values:

- Acceptance of tradeoffs that could violate unique values and rights. For example, all emissions of sulphur dioxide are added, regardless of who or what is exposed. In **Fig. 4**, this means that views at the upper end of the vertical axis are of low interest.
- A moral circle that at least incorporates some of the environment. In Fig. 4 this means that views to the left along the x-axis are of low interest.

If the degree of precaution or the number of unique values and rights are too high, all actions will be suppressed, including actions for sustainable development. This means that views close to the top area and the background area are of low interest to include in an impact assessment.

As a consequence, the right, shaded part of the volume in Fig. 4 is of greatest interest for LCA.

5 Discussion

What would the consequences be of applying the documentation format as illustrated in Fig. 3 and 4? Does it change LCA, or the way LCA is used in practice? Hopefully it may allow for a different view of values. Values are not mysterious defects in science. They are part of reality and can be described and understood.

But how can we describe the value base for choices in LCA with the highest explanatory power? The way indicated in Fig. 3 is designed to allow a quick picture of the value base, but of course, there are much more shades than a single axis may reveal. A qualitative description of what is included in environmental concern, how tradeoffs are made and how uncertainty is handled is also needed and the way of doing this may be developed further.

There are many subconscious processes involved in how we perceive values. A real world 'value choice' in an LCA may therefore be difficult to fully explain on a rational basis in terms of a certain value orientation. But it may still be useful, as it triggers a process of awareness. For instance, it may raise the question if it is reasonable to evaluate sustainability measures with non-sustainability value orientations such as egocentrism or individualism - even if these groups express an interest in LCA (Hoftetter et al. 2000).

6 Conclusions and Recommendations

Values arise from experience about how to deal with problems. Sustainable development as we understand it today has never been a problem to the expansion of Western civilisation. The present classification into egocentrism, anthropocentrism, altruistic anthropocentrism and ecocentrism, or similar classifications based on cultural science, may therefore not be ideal for describing value choices in LCA, which in itself has a value orientation towards sustainable development. The focus and resolution should instead be on value patterns encompassing sustainable development.

General description of held values is not enough to justify choices made in an LCA. We need to describe aspects of held values relevant for specific choices in LCA and we need to make it systematically in close connection to the choices. Otherwise more or less conscious considerations like habits and anticipated outcome of the result may influence the choice.

It is recommended that the value base is described in terms of:

- what is included in the concern for the environment
- how tradeoffs are made
- how uncertainty is handled.

Thinking of value orientations as areas in a value space as described in Fig. 3 and 4 may facilitate their treatment in relation to performing an LCA. It allows for fast communication of the general features without hindering a more detailed description. In this study it has led to two insights:

- As early as at the time of the decision to start an LCA there are value orientations, which, for reasons of consistency, delimit the number of alternative value orientations when performing it.
- To get a full picture of how different value orientations influence the outcome of an LCA one ought to explore separate parts of the value space. These may be either different corners in the value space or represent value orientations of different groups.

The structure outlined in this paper is intended to be a contribution to the development of a language to describe value issues in LCA. Hopefully future studies will follow some of its trajectories.

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